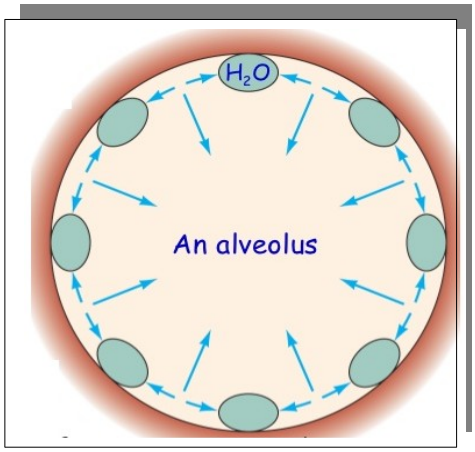
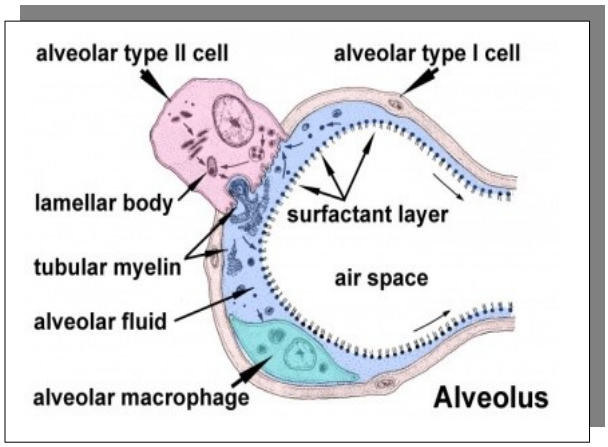
Alveolar Surface Tension and

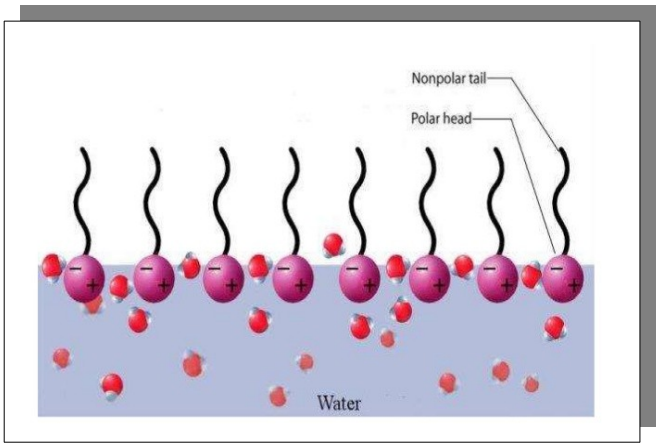
ILOs: By the end of this lecture the student will be able to:

1. Define surfactant & describe its functional structure.
2. List the physiological functions of the surfactant.
3. List factors affecting formation of the surfactant.
4. Describe the role of surfactant in alveolar stability.
5. Explain the respiratory distress syndrome (RDS).

- The attractive forces between water molecules in the liquid film that lines the alveoli are responsible for **surface tension** which make the alveoli resist inflation and tends to collapse.
- The surface tension of water lining the alveoli is reduced by the pulmonary surfactant







Pulmonary surfactant:

➢ **Definition:**

It is a surface tension lowering substance secreted by *type II alveolar epithelium* & spreads over the fluid surface of alveoli.

➢ **Chemical structure:**

- It is a complex mixture of **phospholipids** (lecithin), **proteins** & **Ca++ ions**.
- It has
  - A hydrophilic end (water soluble) (towards the fluid lining alveoli).
  -A hydrophobic end (water insoluble) (towards the air in the alveoli=lumen)

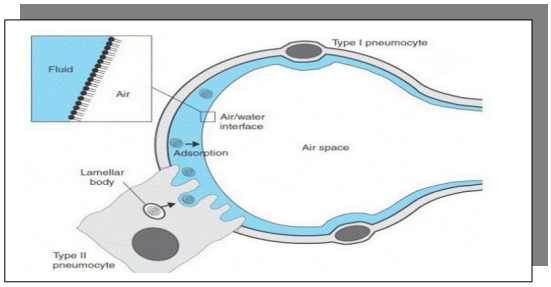
- This arrangement separates the surface H20 molecules decreasing the attractive forces between them, thus reducing the surface tension.

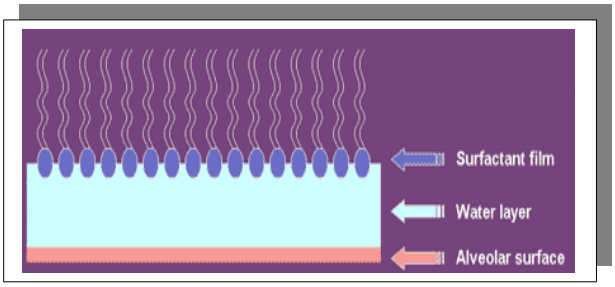
➢ **Origin:**

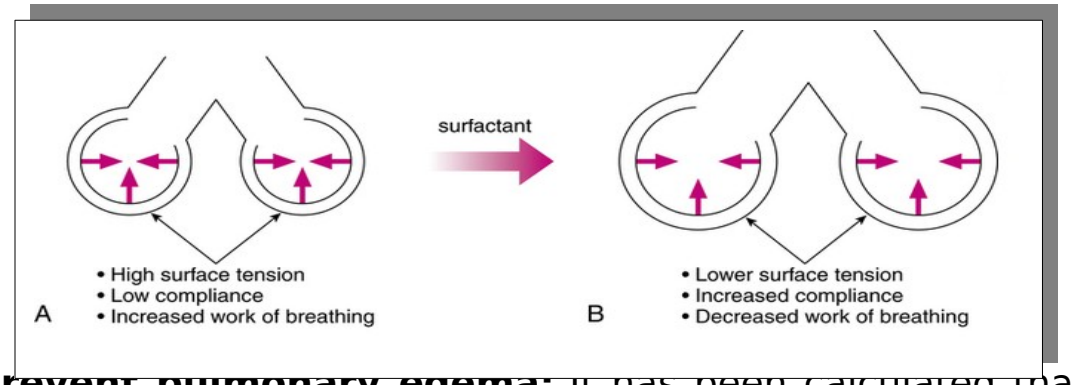
- Surfactant is secreted by **type II alveolar epithelium** (granular pneumocytes).
- Typical lamellar bodies, membrane-bound organelles containing whorls of phospholipid, are formed in these cells and secreted into the alveolar lumen by exocytosis. Following secretion, the phospholipids of surfactant line up in the alveoli with their hydrophobic fatty acid tails facing the alveolar lumen.
- Surfactant formation starts after 24th weeks of intrauterine life & completed at 35th week so full term pregnancy is important to ensure that the surfactant is completely formed.
- Also, cortisol, thyroxine & oxygen (normal ventilation) are needed for full surfactant formation.

➢ **Physiological importance of surfactant:**

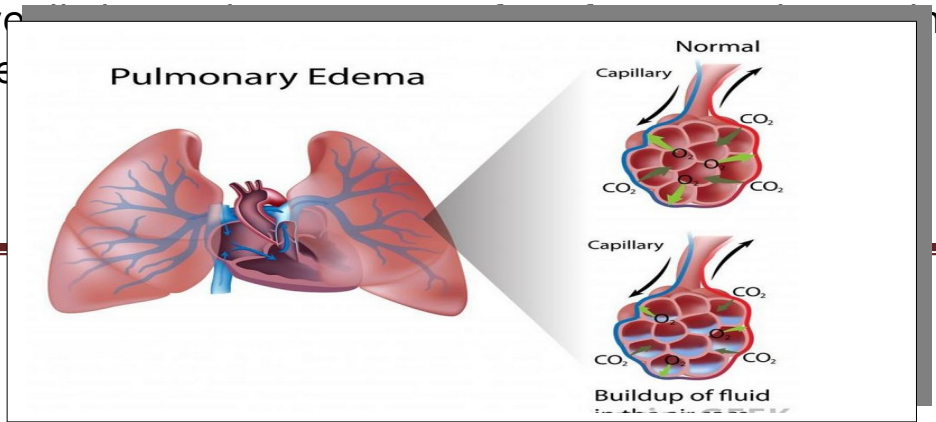
1. **Lower the surface tension in alveoli:** this will decrease recoil force of the lungs →↑lung expansion & dispensability (compliance). Thus, decrease the work of breathing.
   Because it has a <u>hydrophilic end</u> in the fluid lining alveoli & a <u>hydrophobic end</u> in the air in the alveoli so it separates the surface H20 molecules thus decrease the attractive forces between them decreasing the surface tension.





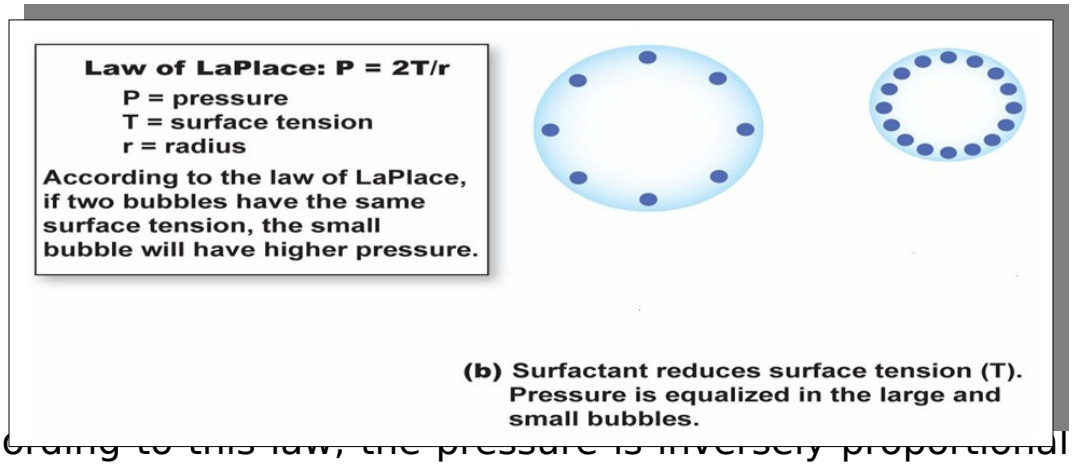


2. **Prevent pulmonary edema:** It has been calculated that if surfactant was not present, the unopposed surface tension in the alveoli would produce a 20 mm Hg force favoring transudation of fluid from the blood into the alveoli. Therefore, the presence of surfactant keeps the alve monary ede



3. **Stabilization of alveolar size & preventing lung collapse:**

- This can be explained by **Laplace law** which states that: "The pressure inside an alveolus (P) is directly proportional with surface tension (T) and inversely proportional with the radius of the alveolus (r) ".



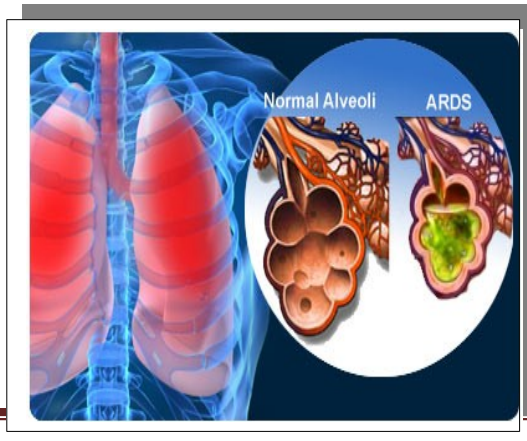
- According to this law, the pressure is inversely proportional to the radius, so the small alveoli (r) have high pressure (p) while the large alveoli have low pressure.
- Therefore, if the surfactant is absent or equally concentrated in all alveoli; air will move from the small alveoli into the large alveoli (leading to collapse of the small ones and rupture of the large ones).
- Collapse of small alveoli (escape of air from them) is prevented by the presence of surfactant and by the fact that surfactant is more concentrated in the small alveoli preventing their volume from being more diminished and less

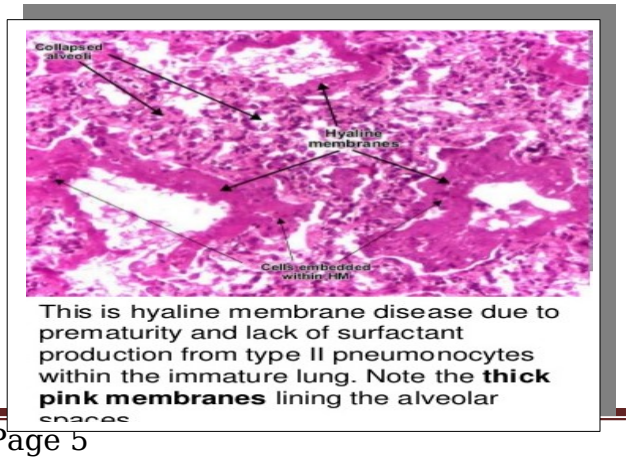
concentrated in large alveoli preventing their volume from being larger.

N.B: *Surfactant equalize the pressure in all alveoli so stabilize the size of alveoli (therefore to make pressure constant according to Laplace law the tension must match the radius so in small alveoli to keep pressure (p) constant the surface tension (T) must decrease to match the small radius (r), this is achieved by surfactant being more concentrated in the small alveoli).*

Respiratory distress syndrome (RDS)

- Surfactant is important at birth. The fetus makes respiratory movements in utero, but the lungs remain collapsed until birth. After birth, the infant makes several strong inspiratory movements and the lungs expand. Surfactant keeps them from collapsing again.





This is hyaline membrane disease due to prematurity and lack of surfactant production from type II pneumonocytes within the immature lung. Note the **thick pink membranes** lining the alveolar spaces

1. **Infant respiratory distress syndrome** (IRDS), also known as **hyaline membrane disease:**

- It is a serious pulmonary disease in which there is deficiency in surfactant formation in the newly born which lead to failure of lung distension, alveolar collapse (atelectasis), pulmonary edema and respiratory failure.

2. **Adult respiratory distress syndrome:**

It is also a serious medical problem occurs in adults who undergo a prolonged surgery (cardiac surgery) involving use of a pump oxygenator a long time of anesthesia and interruption of the pulmonary circulation.

It is commonly seen in patients with occlusion of a main bronchus, occlusion of one pulmonary artery, or long-term inhalation of 100% O_2. Cigarette smoking also decreases lung surfactant.

Factors essential for surfactant formation:

1. *Full term (as surfactant is efficient in function after 35th week of gestation).*
2. *Oxygen (active synthesis needs normal ventilation).*
3. *Hormones e.g cortisol and thyroxine.*

Factors decrease surfactant formation:

1. *Prematurity.*
2. *Lack of thyroxine or cortisol.*
3. *Hyperinsulinism: insulin inhibits surfactant secretion. This explains the increased respiratory distress syndrome(RDS) in infants born to diabetic mothers because of associating fetal hyperinsulinemia.*
4. *Hypoxia (severe oxygen lack) or inhalation of oxygen under pressure for long time (hyperbaric oxygen)*
5. *Lung diseases e.g pneumonia, lung collapse, pulmonary venous congestion.*
6. *Heavy cigarette smoking.*